Water Quality Modeling Challenges in Albemarle Sound

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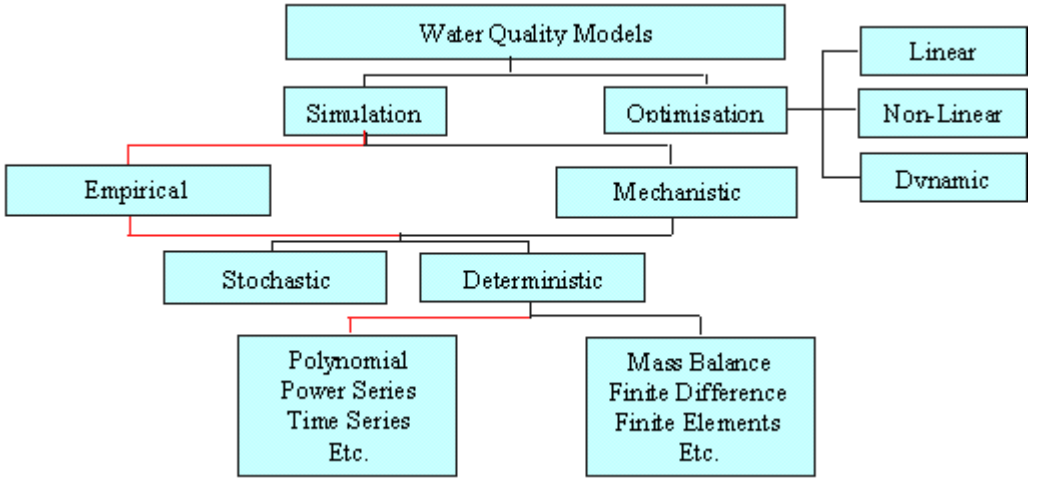
Types of Models

- Process-based Models
  - Watershed Models (e.g. HSPF for High Rock, WARMF for Falls)
  - Receiving Water Models
    - Hydrodynamic Models (e.g. EFDC for Falls and High Rock)
    - Water Quality Models (e.g. WASP for HRL)
- Statistical Models
  - Empirical Models
  - Bayesian Network
  - Stochastic Models



VICAIRE (VIrtual CAmpus In hydrology and water REsources management)

Major Estuarine Processes to be represented with process-based model

- Estuarine Hydrodynamic Processes
  - Freshwater Flow
  - Thermohaline Circulation
  - Harmonic Tides
  - Wind-driven Circulation
  - Vertical Stratification, turbulence
- Biogeochemical Processes
  - Algal growth, respiration, nutrient limitation, …
  - Nitrification, denitrification, benthic flux, …
  - Phosphorus sediment adsorption, …
  - Hypoxia, DO reaeration, …

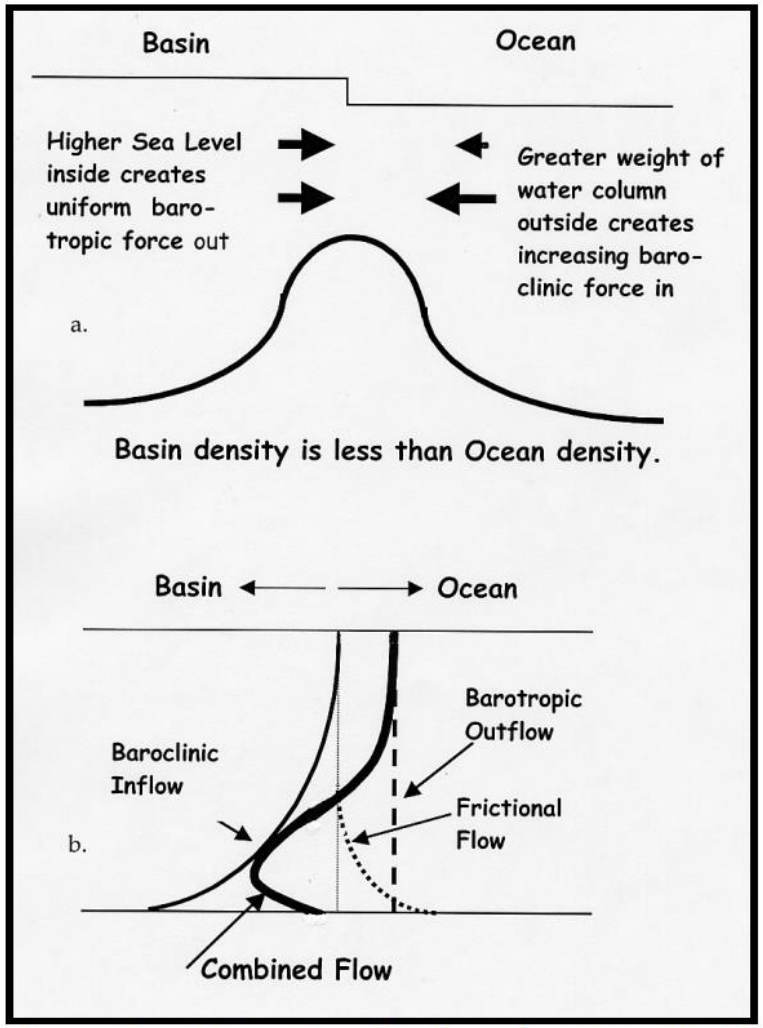


Figure 2. Two-way thermohaline exchange through an inlet: a) the pressure differences, b) the baroclinic, barotropic, frictional and combined velocity profiles. From Figure 2 of Hopkins (2001).

Major Albemarle Processes that would need to be represented (*incomplete list*)

- Estuarine Hydrodynamic Processes
  - Micro-tidal
  - Wind-driven
  - Well-mixed
- Biogeochemical Processes
  - Different algal groups
  - Different nutrient limitation pattern river vs. sound
  - Sediment nutrient flux
  - SAV !!!

Process-based Model?

……

$$\frac{\partial(m_x m_y HC)}{\partial t}+\frac{\partial}{\partial x}(m_y HuC)+\frac{\partial}{\partial y}(m_x HvC)+\frac{\partial}{\partial z}(m_x m_y wC)$$
$$=\frac{\partial}{\partial x}\left(\frac{m_y HA_x}{m_x}\frac{\partial C}{\partial x}\right)+\frac{\partial}{\partial y}\left(\frac{m_x HA_y}{m_y}\frac{\partial C}{\partial y}\right)+\frac{\partial}{\partial z}\left(m_x m_y \frac{A_z}{H}\frac{\partial C}{\partial z}\right)+m_x m_y HS_C$$

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Data Needs and Challenges with Process-based Models

- Bathymetry -- model grid

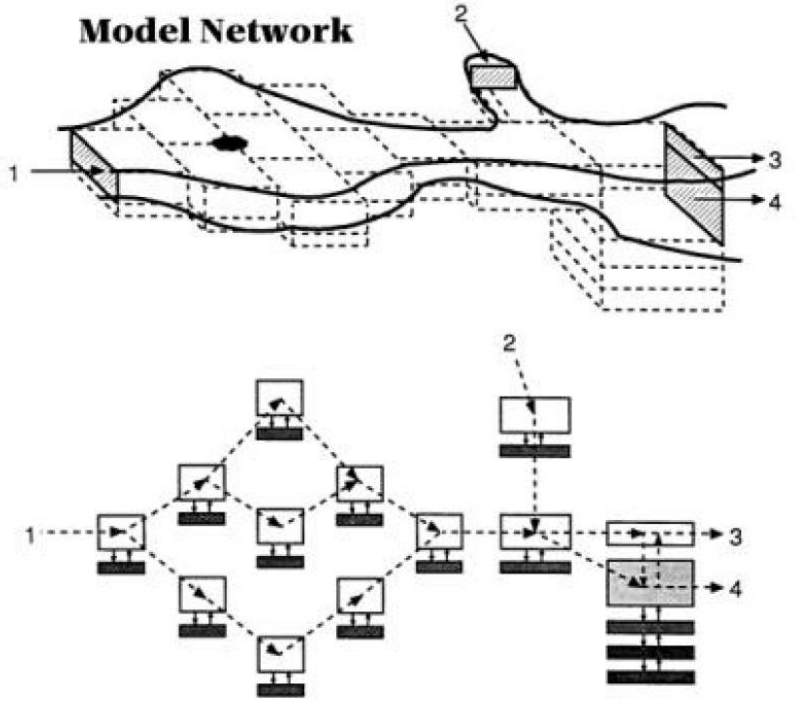
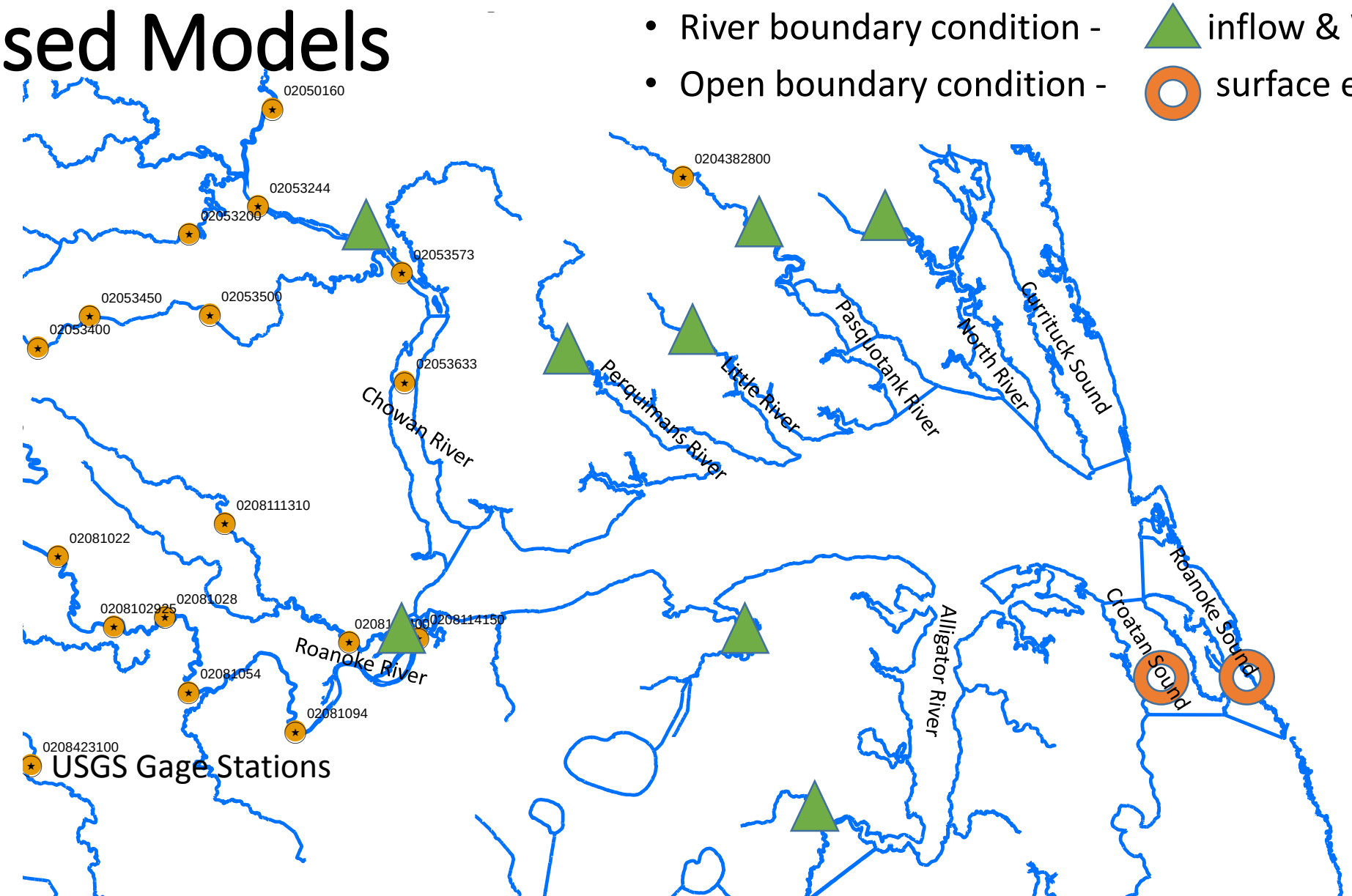


Figure 5-2 Model Segmentation Schematic

(Example model grid from WASP Manual; Much more complex model grid would be expected for Albemarle)

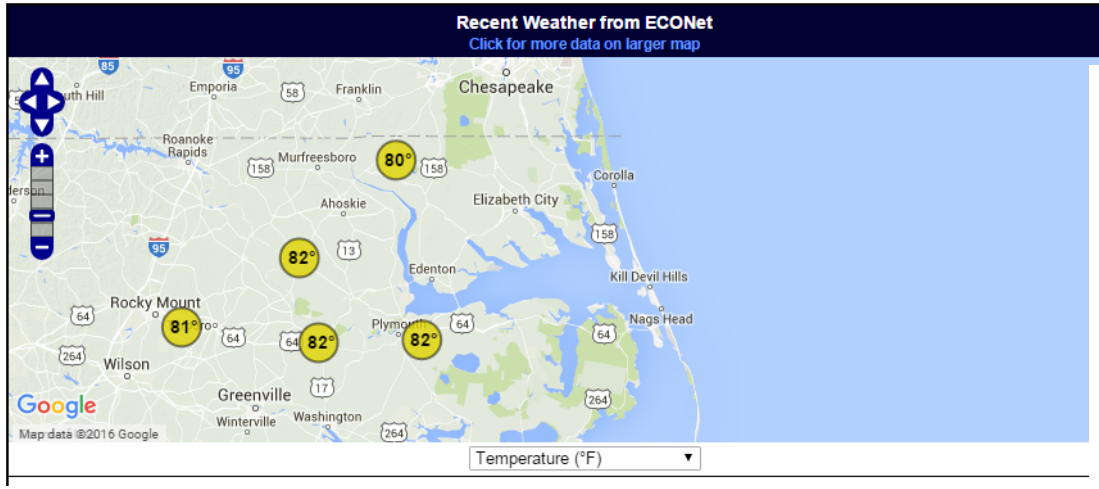
Data Needs and Challenges with Process-based Models

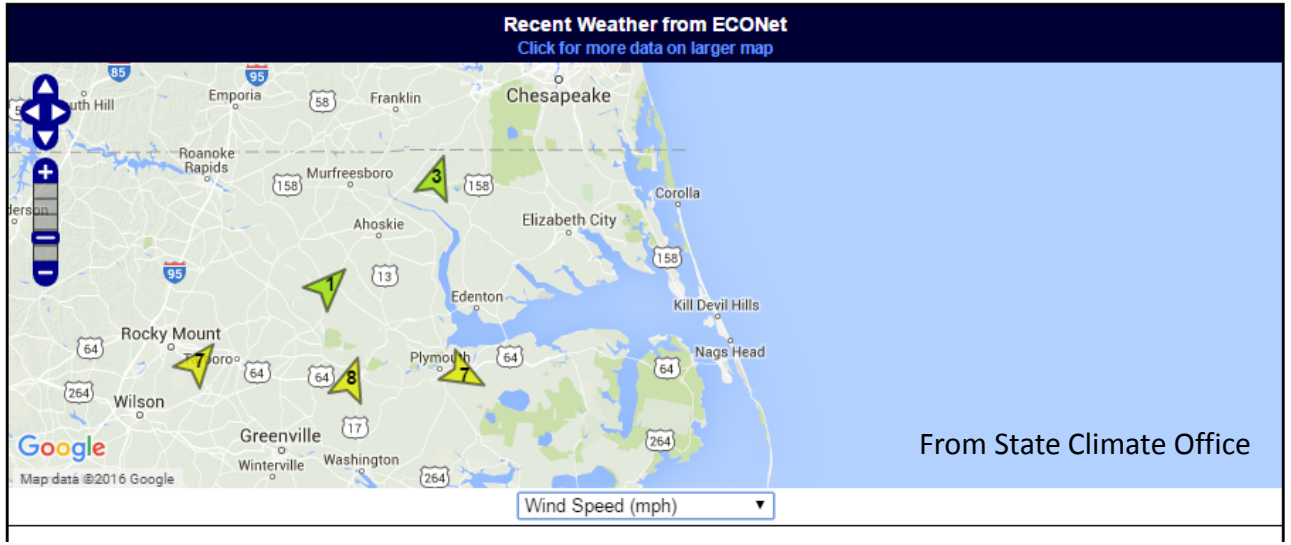
- River boundary condition - inflow & WQ
- Open boundary condition - surface elevation & WQ



Data Needs and Challenges with Process-based Models

- Surface boundary condition --- e.g. wind
- Bottom boundary condition --- e.g. nutrient flux





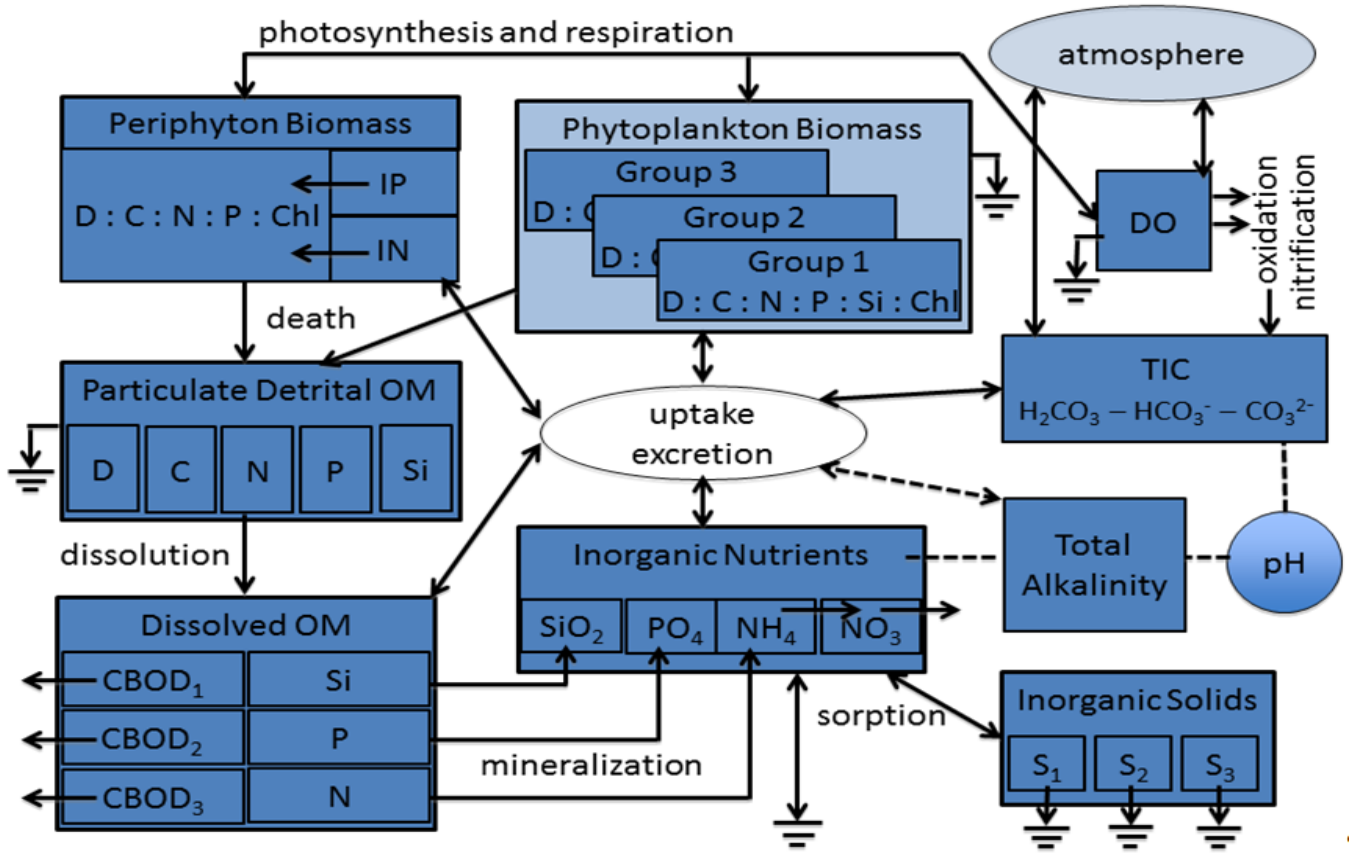
From State Climate Office

Towndock Marine Forecast: (@2pm, April 27, 2016)

Albemarle Sound: Sw Winds Around 10 Kt (11.5mph); Manteo: SSW 20 MPH; Pamlico Sound: Sw Winds 15 To 20 Kt (17.3 to 23mph);

Data Needs and Challenges with Process-based Models

- Model parameterization --- observation, literature, and calibration/validation

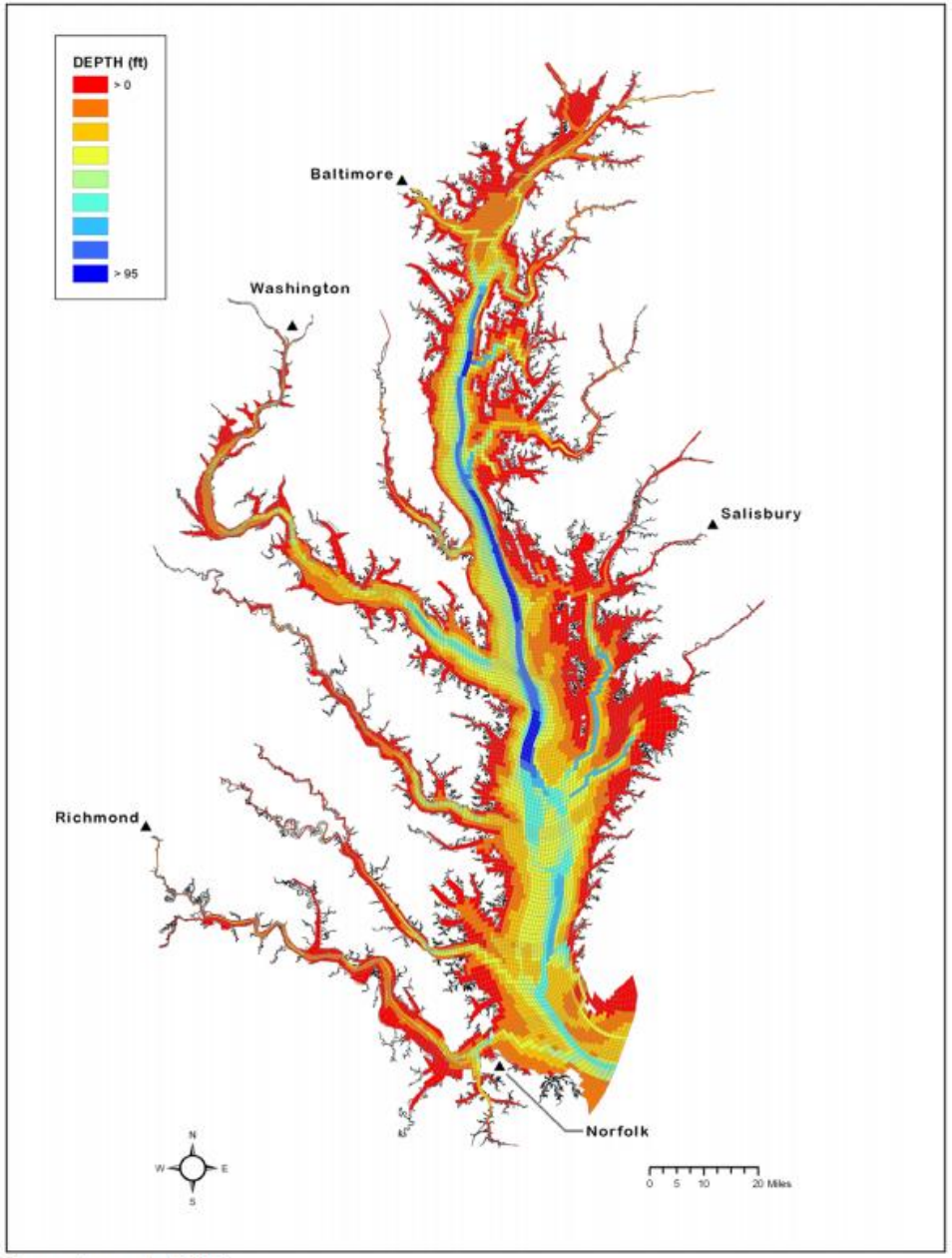


e.g. WQ variables and processes simulated in WASP

Typical Processes of Modeling

- Technical Advisory Committee
  - Monitoring plan
  - Provide data
  - Model selection
  - Model calibration criteria
  - Model Review
- Resources (examples)
  - Chesapeake Bay WQ Model (57,000 cells)
  - Delaware Bay PCB Model (DRBC, LTI, and HydroQual)
  - Gulf of Mexico Hypoxia Modeling (empirical vs deterministic model)

"The Panel concluded that several empirically-based models are ready for transition to operational use in scenario forecasts of nutrient reduction goals required for hypoxia mitigation. Conversely, deterministic modeling efforts were considered to have made considerable recent advancements, but not fully ready for use in an operational environment for scenario-based hypoxia forecasts. " (Aikman et al., 2013)



Source: Cerco et al. 2010

Figure 5-16. The detailed 57,000 cell grid of the Chesapeake Bay Water Quality and Sediment Transport Model.

Thank You

Department of Environmental Quality